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〔54〕名 稱：整體電熱墨水噴射印刷頭及其製造方法

〔21〕申請案號：77105452 〔22〕申請日期：中華民國77年（1988）08月08日

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〔57〕申請專利範圍：

1.一種製造墨水噴射印刷頭之自動對齊方法，乃包含下列步驟者：

a 備製一可重複使用之基板；

b 在該基皮上成形一孔口板；

c 在該孔口板上成形第一界面層；

d 在該第一界面層上成形預先設定形狀之電熱電阻，並相對於該孔口板上之開孔位置定位；

e 在該第一界面層上成形第二界面層，並延伸覆蓋該電熱電阻器，以保護電熱電阻使其不受墨水之腐蝕及白損；

f 在該第二界面層上成形墨水貯存池定層，並使多數墨水貯存池開孔與孔口板上之開孔相對齊；

g 備製經該第一界面層及該第二界面層之流道以及從該貯存池延伸至孔口板開孔，由此該墨水貯存池層可穩固地固著於墨水供應室，以供應墨水於該多數墨水貯存池中；

h 將可重複使用之基板自孔口板上移開。

2.申請專利範圍第1項所述之方法，其再包括將一墨水供應室固著於該貯存池定層上，使從普通之墨水供應源將墨水供應至各貯存池中者。

3.申請專利範圍第1項所述之方法，其包括將電熱電阻器與引導導體在該第一界面層表面上一體成形而由控制電阻器導體物質之截面積以控制電阻器導體之電阻者。

4.申請專利範圍第2項所述之方法，其包括將電熱電阻器與引導導體於該第一界面層表面上一體成形而由控制電阻器導體質之截面積以控制電阻器導體之電阻者。

5.一種墨水噴射筆之製造方法，其包含：

a 在可重複使用之基板上成形一薄膜傳送器結構，包含將導體引導至熱量產生傳送器；

b 在鄰接該傳送器上成形墨水貯存池定壁；

c 移開該基板；

d 將該壁與墨水供應容器固定在一起；

e 將該導體電接至該容器上之接頭，使電流可傳送至該傳送器者。

6.申請專利範圍第5項所述之方法，其中該墨水貯存池定壁係在該薄膜傳送器結構上電積成圖案，然後再固定於該墨水供應容器上者。

7.申請專利範圍第6項所述之方法，其中在該薄膜傳送器結構中之孔口係在可重複使用之基板頂部以選擇性電積成形法所製得者。

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8.申請專利範圍第 5 項所述之方法，其中該傳送器係以沈積多數電阻，其形狀為部分圓環形而圍繞於該薄膜傳送器結構中之多數孔口，並與多數之引導導體一體相連者。

9.申請專利範圍第 8 項所述之方法其中該壁係以電積成形而部份被該電阻器圍繞使墨水流至其中者。

10.一整體電熱墨水噴射印刷頭，其包含：

a 具有多數開孔之孔口板；

b 置於該孔口板上之第一界面層；

c 配置於該第一界面層上預定形狀之電熱電阻器，其與孔口板上之開孔相鄰；

d 置於該第一界面層上之第二界面層，覆蓋住電熱電阻器，而保護使其免受墨水之腐蝕及白損；

e 置於該第二界面層上之墨水貯存池定層，其具有多數墨水貯存池，與孔口板中之開孔相對齊；

f 該第一及第二界面層，具有一流路通至每一該孔口板之開孔，使墨水可自該貯存池定層中之貯存池流經該孔口板上之開孔，由此墨水貯存池定層可緊密固定於墨水供應室或外殼上，以便在墨水噴射印刷操作中墨水可流經該孔口板至該貯存池中者。

11.申請專利範圍第10項所述之結溝， 其再包含一墨水供應室，固著於該墨水貯存池定層上，以供應墨水從普通之墨水供應源至該每貯存池中者。

12.申請專利範圍第10項所述之結構， 其中該電熱電阻係與引導導體一體成形，其電阻係仿其截面積之大小所控制者。

13.申請專利範圍第11項所述結構， 其中該電熱電阻器係與引導導體一體成形，而其電阻係依其截面積之大小所控制者。

14.一種墨水噴射筆，包含：

a 具有導體之薄膜傳送器，引導至電熱產生傳送器，並具有墨水噴射孔口，與該傳送器相連拉；

b 圓環形壁，鄰接於該傳送器，以定墨水貯存池；

c 一墨水容器，固定於該圓環形壁；

d 在該容器上之接頭，將外部之電器接頭接於該薄膜傳送器結構上之該導體者。

15.申請專利範圍第14項所述之筆， 其中該側壁係以電積法成形，具有供墨水流通部份，以供應墨水於該傳送器者。

16.申請專利範圍第14項所述之筆， 其中該傳送器係以電熱電阻器部份圍繞該薄膜傳送器結構之該孔口者。

17.申請專利範圍第16項所述之筆， 其中該側壁係以電積法成形，具有供墨水流通部份，以供應墨水於該電熱電阻器，而部份環繞該電熱電阻器者。

18.申請專利範圍第17項所述之筆， 其中該電熱電阻器係與引導導體一體成形者。

19.申請專利範圍第14項所述之筆， 其中該傳送器係為電熱電阻器而部份環繞該孔口，並與引導導體結合成一體者。

圖示簡單說明：

圖 1 －10及表示本發明實施例之法程序及結構之一系列概略斷面圖。

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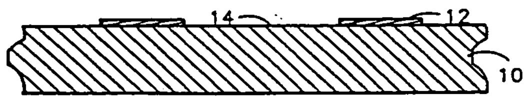

FIG 1

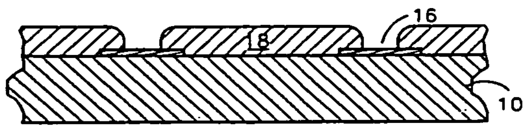

FIG 2

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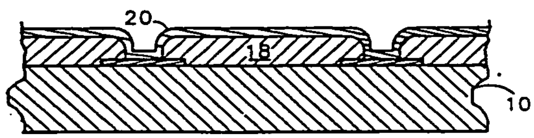

FIG 3

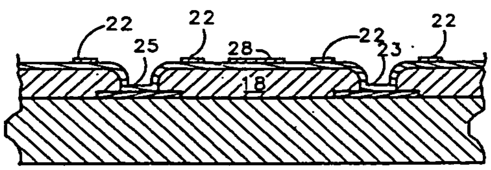

FIG 4A

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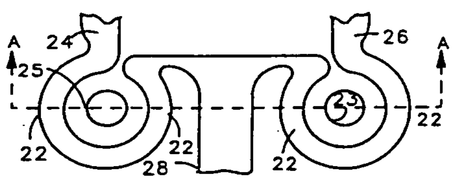

FIG 4B

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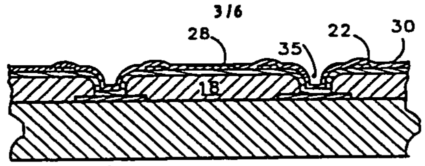

FIG 5A

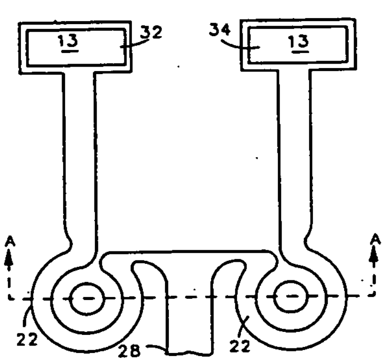

FIG 5B

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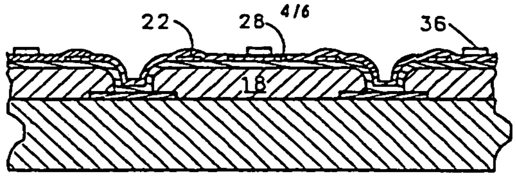

FIG 6

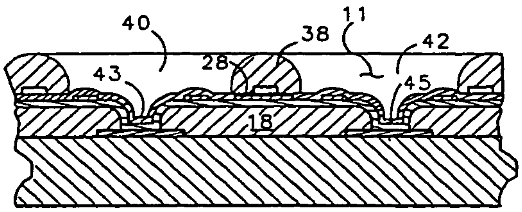

FIG 7

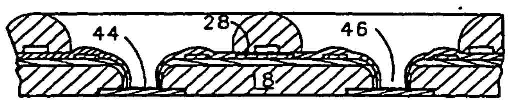

FIG 8

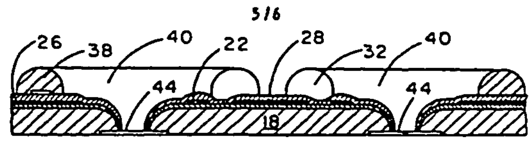

FIG 9A

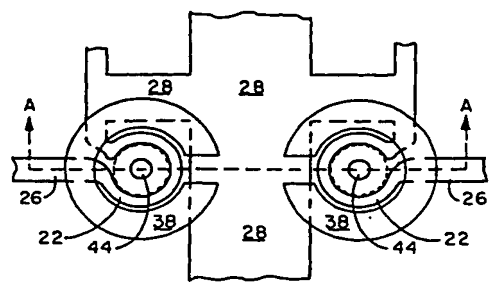

FIG 9B

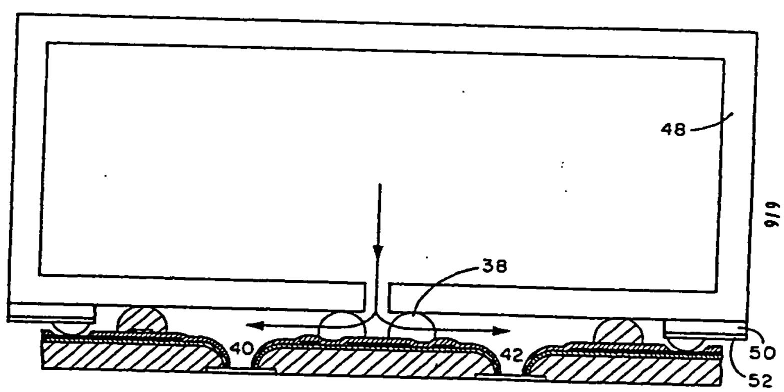

FIG 10

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PATENT
PD# 186230

INTEGRATED THERMAL INK JET PRINTHEAD AND METHOD OF MANUFACTURE

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INTEGRATED THERMAL INK JET PRINTHEAD AND METHOD OF MANUFACTURE

Technical Field

This invention relates generally to thermal ink jet (TIJ) printing and more particularly to a new and improved integrated thermal ink jet printhead and novel method of manufacturing same.

Background Art

In the field of thermal ink jet printing, many present manufacturing processes use a chosen thin film processing technique to make the thin film resistor (TFR) substrate portion of the printhead and a separate orifice plate manufacturing technique to make the metal orifice plate having a desired number and geometry of ink ejection orifices therein. Then, using critical alignment techniques, the orifice plate is precisely aligned with the thin film resistor substrate in such a manner that the heater resistors of the TFR substrate are precisely aligned with the orifices in the orifice plate. Thus, the heater resistors are positioned to heat the ink in associated ink reservoirs which are usually aligned with both the heater resistors and the orifices in the orifice plate. In this fashion, the ink is heated to boiling and forced out of the orifices during a thermal ink jet printing operation. One such fabrication process of the type described above is disclosed in the Hewlett-Packard Journal, Vol. 38, Number 5, May 1985, incorporated herein by reference.

While the above Hewlett-Packard process has proven highly successful in most respects, it nevertheless does require the critical alignment between the orifice plate and the thin film resistor substrate, and it further requires separate processing to form the orifice plate and to form the thin film resistor substrate which are subsequently aligned.

Disclosure of Invention

It is an object of the present invention to provide a new and improved thermal ink jet printhead and process for manufacturing same wherein the above orifice plate processing and thin film resistor substrate processing have been combined into a single novel process sequence. This invention provides a relatively inexpensive and reliable manufacturing process for the large scale production of thermal ink jet printheads, and additionally overcomes the above critical alignment problem of the prior art.

Another object of this invention is to provide a new and improved integrated thermal ink jet printhead and associated manufacturing process wherein the ink jet printhead thus produced has a longer lifetime relative to currently available printheads.

A feature of this invention is the provision of an improved self-aligning process for building up the orifice plate and heater resistors in sequence on a dummy substrate. This process has been greatly simplified relative to currently available printhead orifice plate alignment processes.

Another feature of this invention is the provision of an alignment process which has a very precise alignment of three (3) critical parts of the ink jet printhead, and thus results in an improved performance of such printhead.

The above objects, features and advantages of this invention are accomplished herein by initially providing a reusable or dummy substrate and forming an orifice plate thereon using chosen electroforming techniques. Next, a first insulating barrier layer is formed on the orifice plate, and then heater resistors are selectively spaced on the first barrier layer in a predefined configuration. A second insulating barrier layer is then deposited on the first barrier layer and extends over the heater resistors to protect these resistors from ink corrosion and cavitation wear. Then,

an ink reservoir-defining layer is formed on the second barrier layer and has a plurality of ink reservoir openings therein which are aligned with openings in the orifice plate. Finally, the dummy substrate is mechanically separated from the orifice plate to unplug the openings in the orifice plate, and the ink reservoir-defining layer can now be secured to an ink supply chamber or pen body housing or the like.

The present invention is also directed to a printhead structure made by the above manufacturing process.

The above summary of invention and various objects, features and advantages thereof will become more readily apparent and understood from the following description of the accompanying drawings.

Brief Description of the Drawings

Figures 1-10 herein illustrate, in a sequence of schematic cross-section views, the preferred process and structural embodiments of this invention.

Description of the Preferred Embodiment

Referring now to Figure 1, the substrate starting material 10 may be either silicon or glass and will typically be 200-300 microns in thickness. A photoresist pattern 12 is formed in the geometry shown on the upper surface 14 of the substrate 10, and the photoresist mask 12 serves to define openings 16 in a subsequently deposited nickel pattern 18 which is electroformed on the exposed upper surface 14 in the geometry shown in Figure 2. This process of electroforming nickel on either silicon or glass is generally well known in the art of manufacturing orifice plates for thermal ink jet printheads and is disclosed, for example, in both the Hewlett-Packard Journal cited above and in U. S. Patent No. 4,694,308 issued to Chor S. Chan et al entitled "Barrier Layer and Orifice Plate

for Thermal Ink Jet Print Head Assembly", incorporated herein by reference.

Referring now to Figure 3, a first barrier layer 20 of an insulating film such as silicon nitride or silicon oxynitride or silicon dioxide is deposited on top of the nickel layer 18. Then a thin film resistor/conductor material 22 and 28 respectively which will perform both resistor and conductor functions of a heater resistor and a conductor when properly treated is deposited by sputtering on the upper surface of the insulating layer 20. The resistor portion is indicated as 22 and the conductor portion is indicated as 24, 26 and 28 in Figures 4A and 4B. This thin film resistor/conductor layer is patterned using conventional photoresist masking and etching processes. The thin pattern of resistive heater material 22 is formed in the circular geometry of Figures 4A and 4B and is integrally formed with lead-in conductors 24, 26 and 28 in the geometry shown in Figure 4B.

The circular strip 22 will be the heater resistor by virtue of the fact that it has more number of squares in a given area. That is, the resistance R of both heater resistor 22 and conductor material 24 is equal to Rs L/A, where Rs = sheet resistivity of material, L = length of material, and A = cross section area of material. That is: R = Rs L/A. Therefore, by the appropriate selection of the width and length of openings in the mask used to define the resistor portion (22) and conductor portion (24,26,28) of the integral resistor/conductor strip atop the insulating layer 20 in Figure 4A, the resistance of these segments of the resistor/conductor strip can be controlled as is known in the art.

Referring now to Figures 5A and 5B, a second barrier layer 30 is formed atop the resistor and conductor strips of Figure 4B, and this second barrier layer 30 is preferably a combination of silicon nitride and silicon carbide. The silicon nitride is initially

deposited on the surface of Figure 4A and is followed by a subsequent deposition of silicon carbide so as to provide a highly inert composite Si_3N_4/SiC second barrier layer 30. This barrier layer 30 protects the underlying material against ink corrosion and cavitation wear during an ink jet printing operation. The second barrier layer 30 is then selectively etched in the contact areas 32 and 34 of Figure 5B in order to enable electrical connections to be made to the underlying conductive trace material 24 and 26 for driving the heater resistors 22.

Referring now to Figure 6, a suitable seed strip or pad 36 such as titanium, chromium, or nickel is formed on the barrier layer 30 and photo defined by masking and etching in a well known manner. This seed material 36 is used to initiate the formation, by way of electrolytic deposition and/or electroplating, a larger overlying nickel pattern 38 which is grown in the annular dome shaped geometry shown in Figure 7. The nickel 38 is formed in the shape of partially open annular regions which define a plurality of ink reservoirs or ink chamber areas 40 and 42. These ink chambers 40 and 42 are indicated in Figure 7 and are aligned with the previously formed openings 16 in the nickel orifice plate 18.

The orifice plate 18 along with its adjacent layers of insulating and conducting films can now be separated from the substrate 10 by peeling it off from the same. The substrate 10 basically performs the function of a temporary support substrate for the orifice plate 18 during the process of fabrication and definition of the various thin film layers. This substrate 10 can be used over and over again in the above described process. In the above process of peeling off the orifice plate 18 from the substrate 10, the areas 43 and 45 of the multiple insulating layers on top of the photoresist pads are pulled away from the orifice plate in Figure 7 along with the photoresist

pads 12, thereby leaving openings 44 and 46 in the orifice plate structure shown in Figure 8. The openings 44 and 46 thus formed will therefore be initially left here with the ragged edges shown in Figure 8, but these edges 44 and 46 may be subsequently cleaned off and smoothed out by a mechanical operation such as the use of a light sandblasting with fine grit or plasma erosion.

Figure 9B is a plan view of a preferred embodiment of the invention and shown rotated ninety (90) degrees with respect to the plan views of Figs. 4B and 5B, and Fig. 9A is a cross section view taken along lines A-A of Fig. 9B. The annular shaped domes 38 which serve to define the ink reservoirs or chambers 40 associated with each orifice opening are provided with the ink flow ports 47 and 49. These ports 47 and 49 will typically communicate with a common ink feed path from a remote common ink supply opening (not shown) in a central region of the substrate 18. This common ink supply opening may take the form of an elongated slot which may be defined by known masking and sandblasting procedures. Such ink feed slots and methods for forming same are described respectively, for example, in U.S. Patent No. 4,680,859 of Samuel A. Johnson entitled "Thermal Ink Jet Printhead and Method of Manufacture" and in U.S. Patent Application Serial No. 052,630 of James Pollacek et al entitled "Precision Milling of Materials", both of which are assigned to the present assignee and incorporated herein by reference.

Next, the structure of Figure 9 may be secured to a larger ink supply chamber 48 as shown in Figure 10 using known soldering processes to permanently join the outside wall of the chamber 48 to the metal domes 38. The larger chamber 48 is operative to feed ink in the direction of the arrows 50 and to individual ones of the ink chambers 40 and 42 in the integrated thermal ink jet printhead in Figure 9. Electrical connection means 51, 52 may be mounted on the outer surface of the large

ink reservoir 48 to provide pulse drive circuitry for the printhead of Figure 9. For example, an insulating substrate 51 will typically carry electrical leads 52 thereon (or therein), and in actual practice may take the form of a flexible (FLEX) circuit or a tape automated bond (TAB) bond circuit of the types well known in the art. The individual electrical leads 52 in such circuits may be connected into the printhead conductors 24,26,28 using known wire or beam lead bonding techniques (not shown), and one such suitable single point TAB bonding process is disclosed, for example, in U.S. Patent No. 4,635,073 issued to Gary E. Hanson, assigned to the present assignee and incorporated herein by reference.

The following table of values indicates suitable layer deposition processes, layer thicknesses, and materials which may be used in printhead manufacture in accordance with the presently known best mode for carrying out the present invention. However, it should be understood that this table is given by way of example only, and it is not intended to indicate any single absolute best process for manufacturing our printhead, since one single set of preferred process steps and related details have not been selected as of the present time.

TABLE

LAYER	SUITABLE MATERIAL	DEPOSITION PROCESS	THICKNESS (MICRONS)
Substrate (10)	Oxidized Silicon Glass		200 - 300
Orifice Plate (18)	Nickel	Plating	20 - 75
Insulating Layer (20)	Silicon Dioxide Silicon Nitride Silicon Oxynitride	PECVD * LPCVD **	1 to 3
Resistor/ Conductor (22)	Polysilicon Tantalum Silicide Gold	Sputtering PECVD LPCVD	0.05 to 0.5
Passivation Layer (30)	Silicon Dioxide Silicon Nitride Silicon Oxynitride Silicon Carbide	PECVD LPCVD	0.5 to 2
Seed Layer (36)	Nickel, Titanium Chromium	Sputtering	0.5 to 2
Barrier (38)	Nickel	Plating	10 to 75

* Plasma Enhanced Chemical Vapor Deposition
** Low Pressure Chemical Vapor Deposition

In the above table, PECVD signifies plasma enhanced chemical vapor deposition, whereas LPCVD signifies low pressure chemical vapor deposition. These processes are generally well known in the thin film art and are therefore not described in further detail herein. However, for a further discussion of these or related thin film technologies, reference may be made to the following three books on thin film technology:

(1) Berry, Hall and Harris, Thin Film Technology, Van Nostrand Reinhold Co., New York, 1968.

(2) Maissel and Glang, Handbook of Thin Film Technology, McGraw Hill Book Co., New York, 1970.

(3) Vossen and Kern, <u>Thin Film Processes</u>, Academic Press, New York, 1978.

Thus, there has been described a thermal ink jet printhead which is fabricated in its entirety on one supporting dummy substrate which may be reusable many times, thereby reducing the manufacturing cost of the ink jet printhead. The masking steps used in the manufacture of the ink jet printhead described herein comes to a total of four (4) as compared to six (6) steps using the previously known processes for separately forming a thin film resistor substrate and a matching metal orifice plate, respectively. In the prior art processes, the orifice plate and the heater resistors are fabricated on different substrates and thus have to be precisely aligned with each other, resulting in a time consuming and difficult operation. However, in accordance with the present invention, all of the critical parts of the ink jet printhead which require precise alignment, namely the orifice plate, the ink jet chambers and the heater resistors are all formed on the same substrate, thereby providing a novel self-aligning process. The precise alignment of the above three (3) critical parts result in a precisioned thin film structure capable of improved performance in terms of printhead life and ink drop trajectory. After the ink drops are ejected from the orifices of the above-described printhead, the collapsing ink meniscus at the orifice travels toward the ink supply chamber instead of directly at the heater resistor. In this manner, the heater resistors are not subject to direct cavitational forces during an ink jet printing operation, and thus the life of the ink jet printhead is substantially enhanced.

Claims

1. A self-aligning process for manufacturing a thermal ink jet printhead including the steps of:

a. providing a reusable substrate;

b. forming an orifice plate on said substrate;

c. forming a first barrier layer on said orifice plate;

d. forming heater resistors on said first barrier layer in a predefined configuration and spacing relative to openings in said orifice plate;

e. forming a second barrier layer on said first barrier layer and extending over said heater resistors to protect said heater resistors from ink corrosion and cavitation wear;

f. forming an ink reservoir-defining layer on said second barrier layer and having a plurality of ink reservoir openings aligned with openings in said orifice plate;

g. providing passages through said first and second barrier layers and extending from said reservoirs and to openings in said orifice plate, whereby said ink reservoir layer may be secured to an ink supply chamber for supplying ink to said plurality of ink reservoirs; and

h. removing said reusable substrate from said orifice plate.

2. The process defined in claim 1 which further includes affixing an ink supply chamber to said reservoir-defining layer for providing ink to each of said reservoirs from a common source of ink supply.

3. The process defined in claim 1 which includes forming heater resistors integral with lead-in conductors on the surface of said first barrier layer and controlling the resistor/conductor resistance by controlling the cross-section areas of the resistor/conductor material.

4. The process defined in claim 2 which includes forming heater resistors integral with lead-in conductors on the surface of said first barrier layer and controlling the resistor/conductor resistance by controlling the cross-section areas of the resistor/conductor material.

5. A process for manufacturing an ink jet pen which includes:

a. forming a thin film transducer structure on a reusable substrate and including conductors leading into heat generating transducers;

b. forming ink-reservoir defining walls adjacent to said transducers;

c. removing said substrate;

d. bonding said walls to an ink supply container; and

e. electrically connecting said conductors to mating leads on said container for providing current to said transducers.

6. The process defined in claim 5 wherein said ink reservoir defining walls are electroformed in a pattern on said thin film transducer structure and subsequently bonded to said ink supply container.

7. The process defined in claim 6 wherein orifice openings in said thin film transducer structure are made by selective electroforming on top of said reusable substrate.

8. The process defined in claim 5 wherein said transducers are formed by depositing a plurality of resistors in partially encircling geometry surrounding a corresponding plurality of orifices in said thin film transducer structure and integrally joined with a plurality of lead-in conductors.

9. The process defined in claim 8 wherein said walls are electroformed to partially surround said resistors and provide ink flow thereto.

10. An integrated thermal ink jet printhead comprising:

a. an orifice plate having plurality of openings therein;

b. a first barrier layer disposed on said orifice plate;

c. a plurality of heater resistors arranged in a predefined configuration on said first barrier layer and positioned adjacent said openings in said orifice plate;

d. a second barrier layer disposed on said first barrier layer and covering said heater resistors and protecting same from ink corrosion and cavitation wear;

e. an ink reservoir-defining layer disposed on said second barrier layer and having a plurality of ink reservoirs therein aligned with said openings in said orifice plate; and

f. said first and second barrier layers having a passageway extending therethrough at each opening in said orifice plate for providing an ink flow path from said reservoirs in said reservoir-defining layer and through openings in said orifice plate, whereby said ink reservoir defining layer may be secured to an ink supply chamber or housing for supplying ink to said reservoirs and through said openings in said orifice plate during an ink jet printing operation.

11. The structure defined in claim 10 which further includes an ink supply chamber affixed to said ink reservoir-defining layer for supplying ink from a common source of ink supply to each of said reservoirs.

12. The structure defined in claim 10 wherein said heater resistors are formed integral with lead-in conductors, the resistance of which is controlled in accordance with their established cross sectional area.

13. The structure defined in claim 11 wherein said heater resistors are formed integral with lead-in conductors, the resistance of which is controlled in accordance with their established cross sectional area.

14. An ink jet pen including in combination:

a. a thin film transducer structure having conductors thereon leading into heat generating transducers and further having ink ejection orifices associated with said transducers;

b. annular walls adjacent said transducers and defining ink reservoirs therefor;

c. an ink container bonded to said annular walls; and

d. means on said container for providing an external electrical connection to said conductors on said thin film transducer structure.

15. The pen defined in claim 14 wherein said walls are electroformed to have ink flow ports therein for supplying ink to said transducers.

16. The pen defined in claim 14 wherein said transducers are heater resistors which partially surround said orifices in said thin film transducer structure.

17. The pen defined in claim 16 wherein said walls are electroformed to have ink flow ports therein for supplying ink to said heater resistors and which partially surround said heater resistors.

18. The pen defined in claim 17 wherein said heater resistors are integrally joined to lead in conductors.

19. The pen defined in claim 14 wherein said transducers are heater resistors which partially encircle said orifices and which are integrally joined to lead-in conductors.

Abstract

We describe an integrated thermal ink jet printhead and manufacturing process therefor which includes the successive build-up of an orifice plate, a first barrier layer, heater resistors, a second barrier layer, and an ink reservoir-defining layer on top of a reusable or "dummy" substrate. Lead-in conductors are formed integral with the heater resistors by controlling the cross- sectional areas of these components, and openings (passageways) are formed between ink reservoirs and the orifice plate to provide for ink flow under control of the heater resistors. The dummy substrate is stripped away from the adjacent orifice plate, and the ink reservoir defining layer may be secured to an ink supply tank which supplies ink to the individual ink reservoirs. Thus, the orifice plate, heater resistors and ink flow paths of the printhead are self aligned, and the heater resistors are removed from direct cavitational forces from ink ejected from the orifice plate.

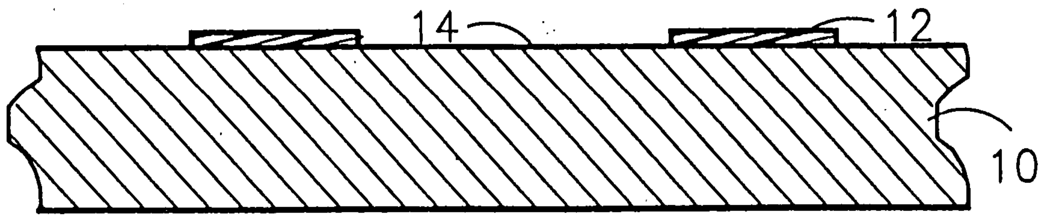

FIG 1

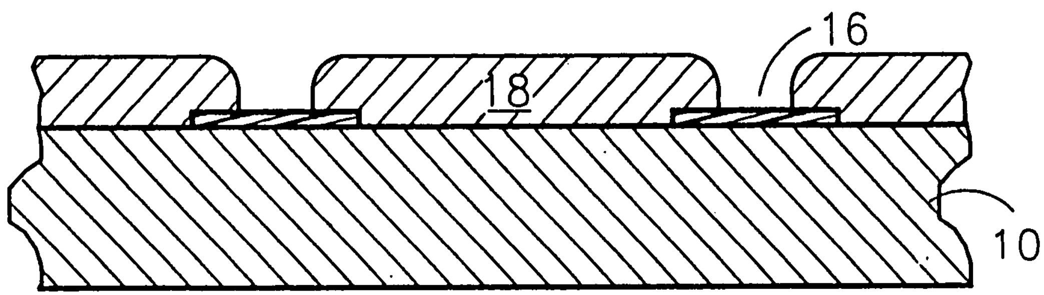

FIG 2

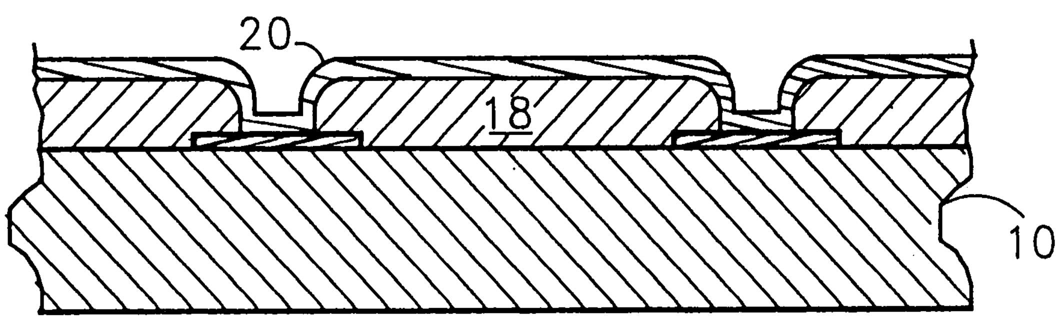

FIG 3

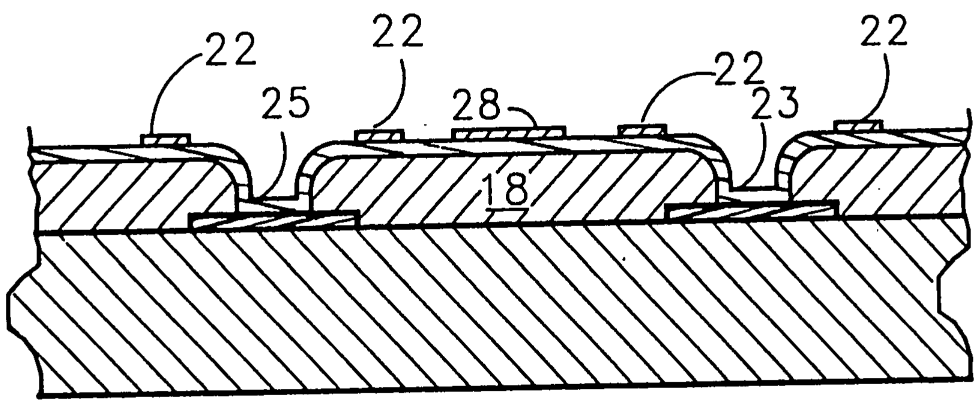

FIG 4A

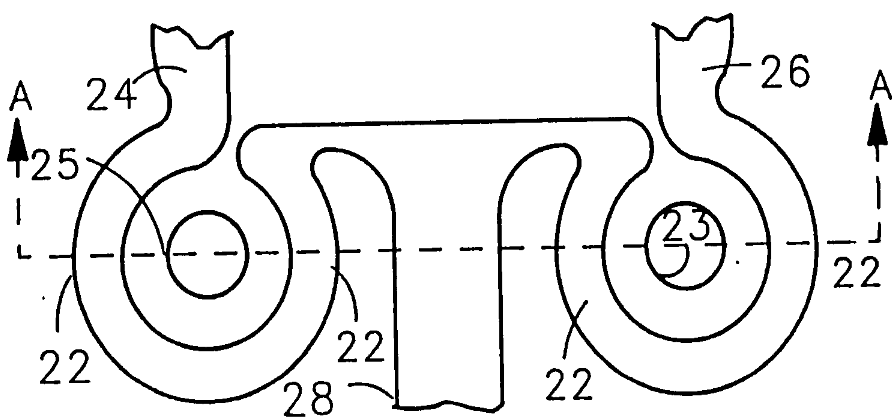

FIG 4B

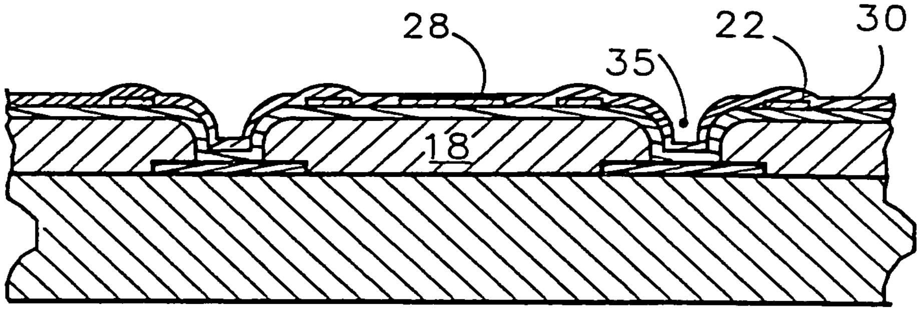

FIG 5A

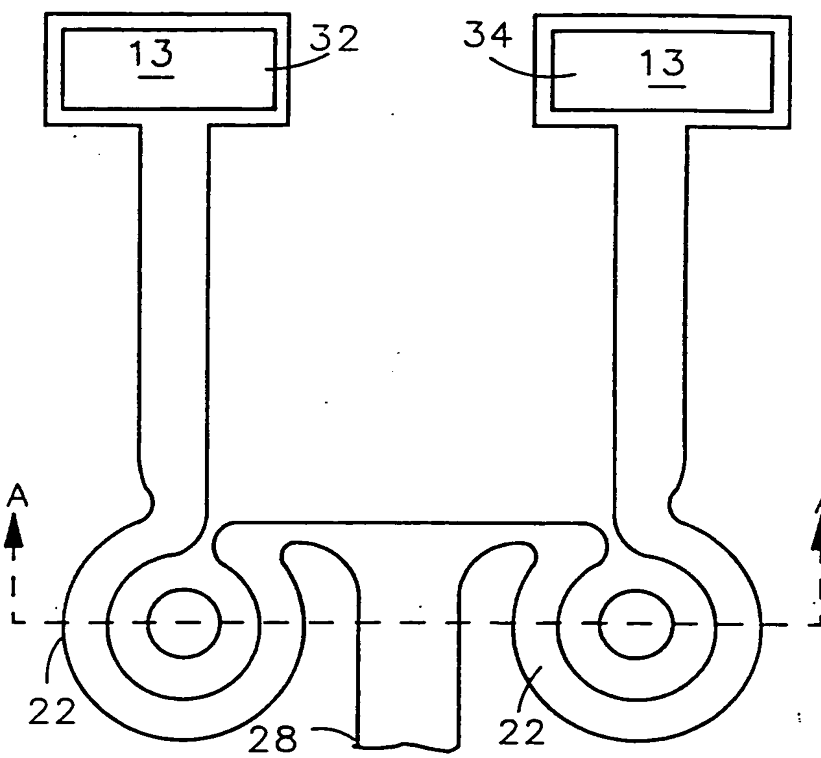

FIG 5B

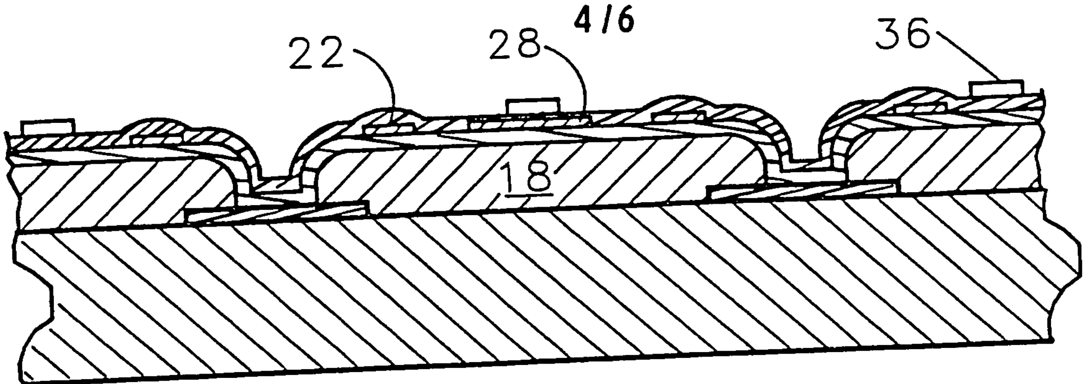

FIG 6

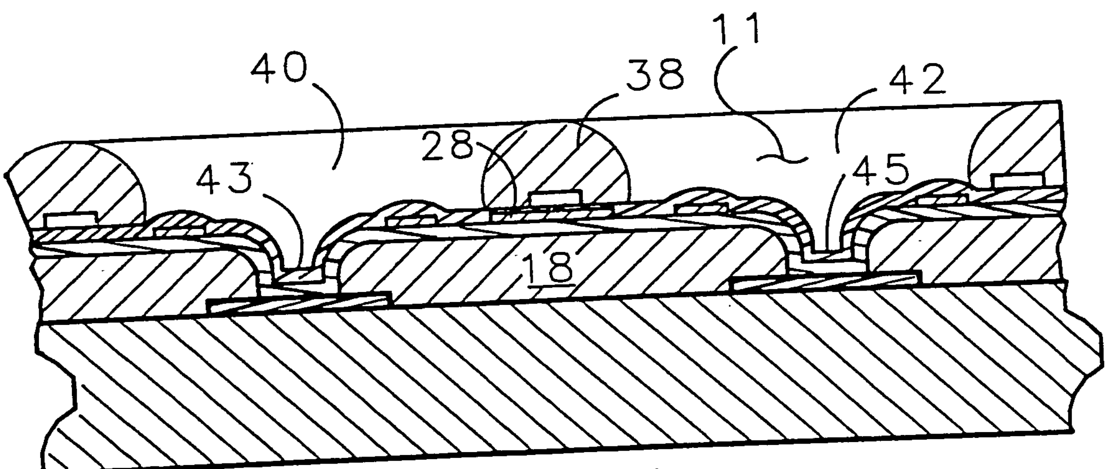

FIG 7

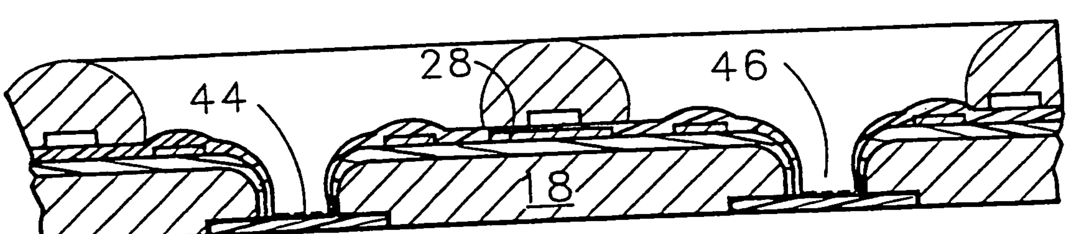

FIG 8

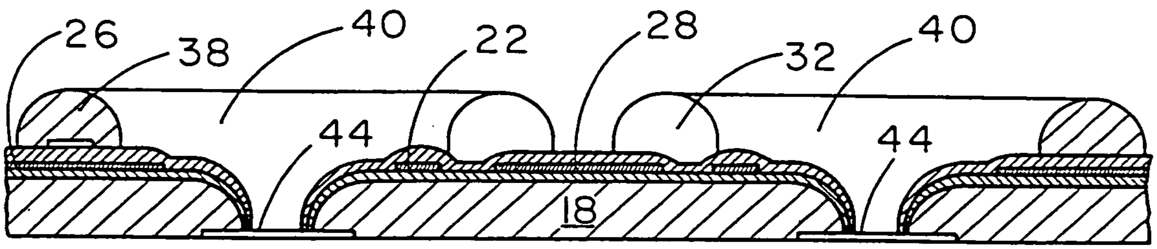

FIG 9A

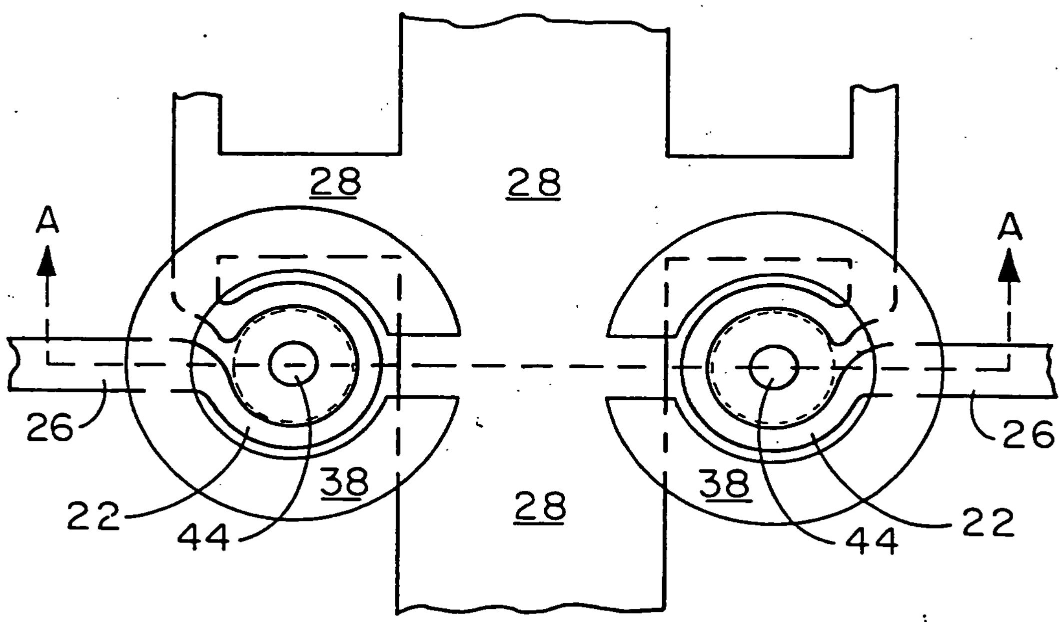

FIG 9B

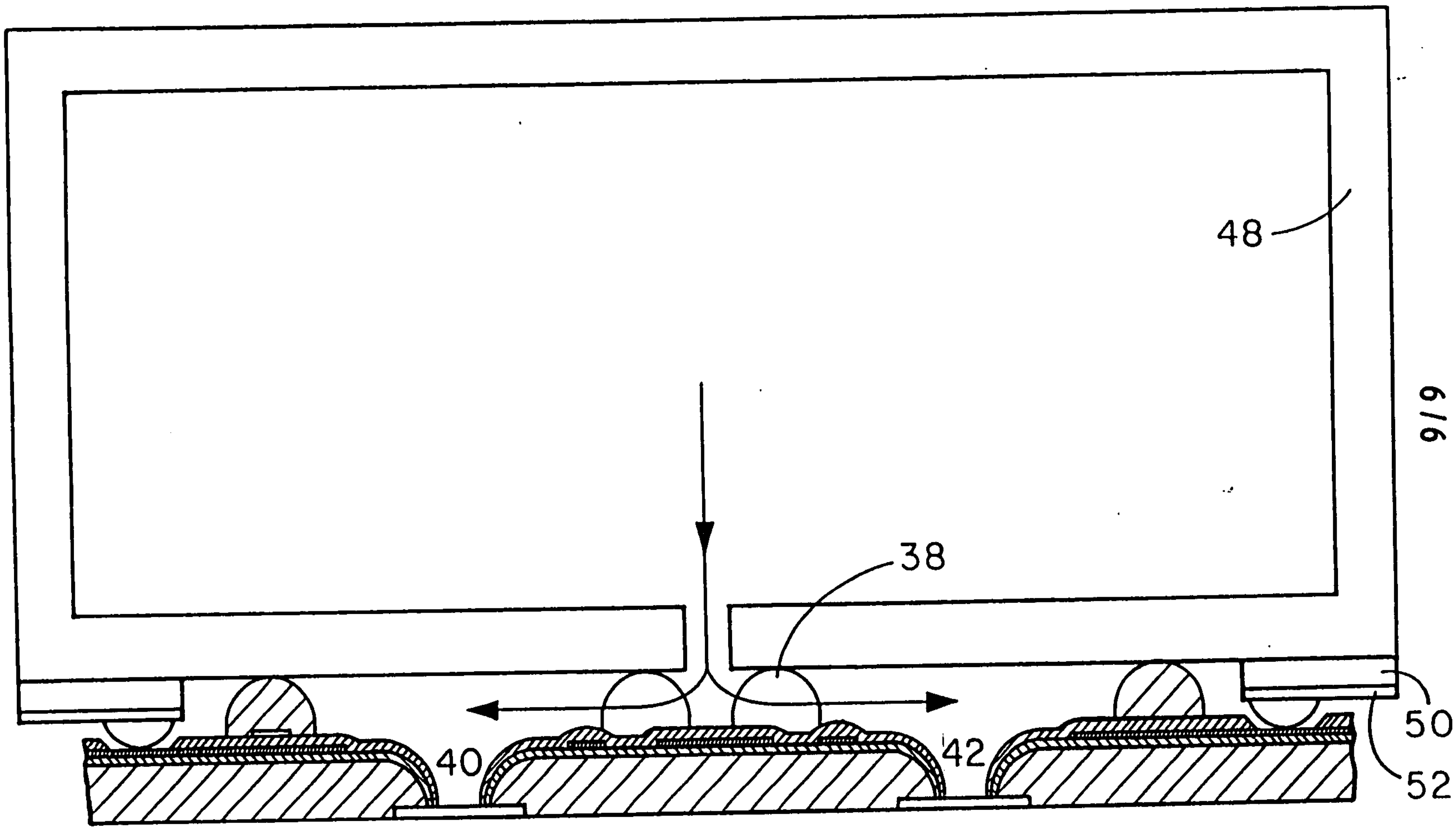

FIG 10